Next Generation Space Telescope

Near Infrared Camera
Interface Requirements Document

Draft Release 2

Goddard Space Flight Center
Greenbelt, Maryland 20771

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MODIFICATION LISTING

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Draft Release 1a (06/18/01) to Draft Release 2 (10/xx/01)

- Assigned NGST Document Number
- Document Repaginated
- Section 2 – Reformatted – added Flight Software reference documents
- Section 3.2.1 – Assumptions made in the optical design of the RT – Revised 3rd bullet to indicate 20-micron NIR pixels
- Section 3.2.1 – Reference Telescope Performance – Revised to indicate WFE as an RMS value
- Section 3.2.2 – second paragraph, corrected reference to NIRSpec to read NIRCam
- Section 3.2.3 – 3rd paragraph replace in its entirety.
- Section 3.2.4 – For AO Proposal submission, WFS hardware to be treated as NASA provided
- Section 3.2.4.1 – Added footnote to provide additional information about the focus mechanism stroke requirement
- Section 3.2.5 – Revised to indicate allocation as an RMS value
- Section 3.3.6 – Revised in its entirety
- Section 3.3.7.1 – Corrected Optics Assembly mass allocation – Added kinematic mount mass
- Section 3.3.8 – Added momentum environment from Observatory to Instrument
- Section 3.4.1 – Added nominal radiator temperature
- Section 3.4.2.2 – Revised
- Section 3.4.4 – Clarification of maximum steady state heat dissipation as the time-averaged heat dissipation
- Section 3.5.3.1 – Added connector for FPA Interface(s)
- Section 3.5.4.1 – Revised second sentence
- Section 3.5.4.2 – Revised second paragraph
- Section 4.3.1 – Clarified FPA/radiator thermal straps as NASA provided items – Clarified heat transfer allocation as total for all FPAs
- Section 4.3.3 – Clarification of FPA temperature stability requirement
- Section 5.0 – Replaced
- Multiple Places: Miscellaneous typographical corrections
- Minor grammatical/typographical changes to paragraphs 5.1, 5.1.3.1, 5.1.3.2, 5.2.1, 5.3.1. General edit to comply with CM Office style guidelines.
- Added ISIM Shared Systems Manager to signature page
- Incorporated Instrument Command Electronics (ICE) box sections 1.2, 3.3.2.2, 3.3.3, 3.3.7.1.2, 3.4.2, 3.5.1, 3.5.1.1, 3.5.4, 3.5.4.1, 3.5.4.2, 3.5.4.3, Replaced Figures 3-3, 3-4 3-5 with single figure
- Updated/revised reference to NGST Detector Development Requirements
- Added Sections 3.5.6 Radiation Environment and 3.5.7 Electromagnetic Interference
- Section 3.5.8 revised to describe NASA-provided Test Set for instrument I&T

TBD/TBR LIST

TBD #	Section	Summary	Actionee	Due Date
1	CM statement	Mail Stop code undetermined		
2	1.2	Single or multiple ICE		
3	3.3.5	ICE envelope dimensions		
4	3.3.2.1.1	WFS&C pupil mechanism location accuracy		
5	3.3.7.1.2	ICE mass allocation		
6	3.5.4.2	ICE power allocation		
7	3.3.8	Angular Momentum imparted from Observatory to SI		
8	3.3.8	Angular Momentum imparted from SI to Observatory		
9	3.3.8	SI set-up time allocation		
10	5.2.1	SpaceWire interface		
11	6.2	Number of SI operating modes		

1.0 INTRODUCTION

The Integrated Science Instrument Module (ISIM) is the payload of the Next Generation Space Telescope (NGST).

The ISIM includes the following:

- Facility Sensor
  - Fine Guidance Sensor (FGS)
- Science Instruments (SI)
  - Near Infrared Camera (NIRCam)
  - Near Infrared Spectrometer (NIRSpec)
  - Mid Infrared Instrument (MIRI)
- Associated/shared subsystems
  - Structure
  - Thermal Control
  - Command and Data Handling (C&DH) hardware and software
  - Front-end electronics (Analog/Digital [A/D] conversion)
  - Focal plane (detector) control electronics.

1.1 SCOPE

This document establishes the specific interface requirements between the ISIM and the NIRCam. These interfaces involve physical, optical, functional, and procedural requirements imposed on the NIRCam design. The NIRCam optically interfaces with the NGST Optical Telescope Element (OTE) by way of a pick-off mirror that is an integral element of the NIRCam. All other interfaces, including, but not limited to, mechanical/structural, control, data storage, data transmission, power, and thermal control, are with the ISIM. **NOTE**: the ISIM Structure, to which the NIRCam is attached, attaches to the OTE back plane structure and serves as the “optical bench” for OTE/NIRCam optical alignment.

This document also establishes the specific interface requirements for the accommodation of the National Aeronautics and Space Administration (NASA) provided detector/Focal Plane Assembly (FPA).

In addition to the Principle Investigator (PI) proposed science functionality for the NIRCam, there is an additional instrument function that shall be incorporated within the NIRCam that enables the NGST science mission.

- Required function: Wavefront Sensing

This document draws upon Phase-A level design information for the NGST and the ISIM. Following the selection of the NGST Observatory Prime Contractor, this document will be modified to reflect the selected design for the OTE and the ISIM.

1.2 NIRCAM ELEMENTS

The NIRCam has three separately packaged elements:

- *Optics Assembly*: optical elements (mirrors, filters, etc.), mechanisms, detector/FPA

- *Focal Plane Electronics* (FPE): command and control and data readout electronics for FPA

- *Instrument Control Electronics (ICE):* an electronics box containing cards for serial communications interface to the ISIM C&DH, mechanisms command and control, calibration system command and control, engineering housekeeping data, and power distribution.

The Optics Assembly and the ICE are PI-provided components/elements.

The FPA and the FPE are NASA-provided components/elements.

The PI may propose the NIRCam as multiple modules. Each module shall have the above Optics Assembly and FPE components/elements. A single (TBR) ICE will control all NIRCam modules.

2.0 APPLICABLE DOCUMENTS

The following documents provide information applicable to the contents of the document as well as basic information used in its generation. These documents are subject to periodic revision, the user, therefore, should refer to the latest available version. In the event of a conflict between documents referenced herein and the requirements of this document, the requirements of this document shall take precedence.

2.1 DOCUMENTS

2.1.1 GSFC Documents

Document Number	Document Title
NGST-RQMT-000633	NGST Level 1 Requirements
NGST-RQMT-000634	NGST Level 2 Requirements
NGST-RQMT-000698	NGST Flight Software Coding Standards
Unassigned	ISIM Flight Software Functional Description
NGST-SPEC-000692	Software Requirements Specification for the Flight Software for the Common Command and Data Handling System
NGST-ICD-000695	NGST Common Command and Data Handling Interface Control Document
NGST-RQMT-000787	Technology Development Requirements and Goals for the NGST Detectors
NGST-RPT-000453	Radiation Environment for the Next Generation Space Telescope
GEVS-SE	General Environmental Verification Specification for STS and ELV Payloads, Subsystems, and Components

2.1.2 Non-GSFC Documents

Document Number	Document Title
MIL-STD-1246	Product Cleanliness Levels and Contamination Control Program

2.2 DRAWINGS

No drawings applicable as of this draft

2.2.1 GSFC Drawings

Drawing Number	Drawing Title

2.2.2 Non-GSFC Drawings

Drawing Number	Drawing Title

3.0 INSTRUMENT INTERFACE DESIGN REQUIREMENTS

3.1 COORDINATE SYSTEM

For responses to the NIRCam Announcement of Opportunity (AO), the NIRCam shall use the Reference Telescope (RT) coordinate systems as shown in Figure 3-1. Following NGST Observatory Prime Contractor selection, the coordinate system will be modified to reflect the selected flight OTE.

The RT optical coordinate system is a right-handed coordinate system with the origin at the vertex of the primary mirror. The +z direction is away from the primary mirror vertex in the direction of the RT focal surface. The RT design is axially symmetric about the z-axis, but the field is biased by a negative tilt about the x-axis to prevent obstruction of light between the tertiary mirror and the fast steering mirror (FSM).

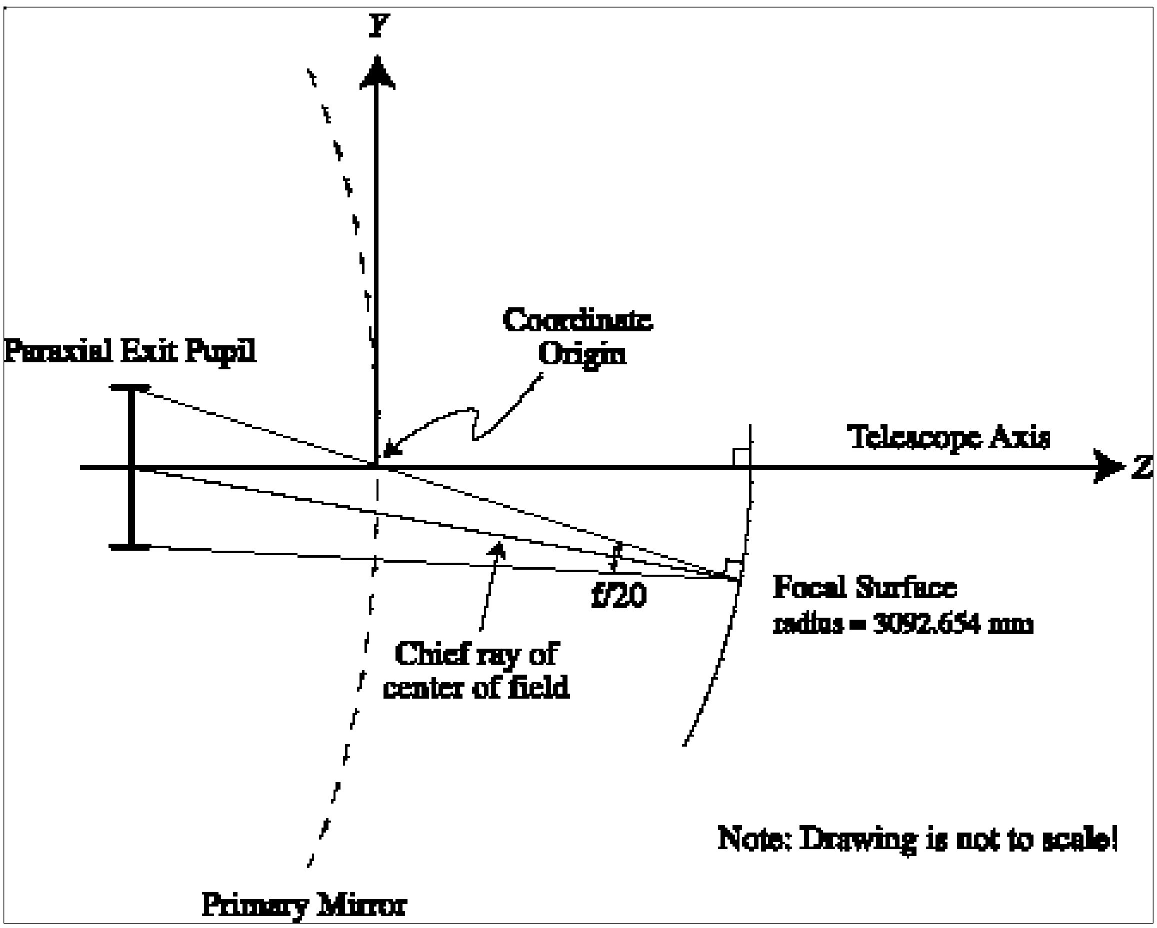

Figure 3-1. Reference Telescope

3.2 OPTICAL INTERFACES

3.2.1 Description of Reference Telescope Design

For the purposes of this AO, the RT is a 3-mirror anastigmatic design with conic surfaces and shall be used for NIRCam definition. Following NGST Observatory Prime Contractor selection, the flight OTE will be redefined using similar parameters.

- Assumptions made in the optical design of the RT:
  - Top Level Requirements
    - 6.0 meter (m) entrance pupil diameter
    - Critical sampling at 2.0 microns wavelength
    - 20 micron square NIR detector pixels
    - Unit magnification for NIRCam relay optics
  - Derived Requirements:
    - Telescope f –ratio: 20.0
  - Design Strategy
    - Match image surface radius of curvature to exit pupil distance
    - Place FSM at exit pupil
    - Assume axial symmetry, correct third order aberrations (spherical, coma, and astigmatism), and locally optimize conic constants
- RT parameters (defined with respect to the standard optical design coordinate system as defined in Section 4.1):
  - Radius of Curvature of the image surface = -3092.654 milli-meters (mm). (Concave towards the exit pupil). Imaging surface intersects the Z-axis at Z=2008.615mm.
  - Distance along the Chief Ray from the exit pupil to the focal plane at the center of the field = 3092.654mm. All Chief Rays are from the center of the field of each instrument.
  - Chief Ray Focal Surface Coordinates

	X-Coordinate	Y-Coordinate	Z-Coordinate
NIRCam	0.000	-216.876	2001.210
NIRSpec	-196.698	-173.792	1997.456
MIRI	173.455	-209.240	1996.649

  - Chief Ray Direction Cosines

	X-cos	Y-cos	Z-cos
NIRCam	0.000000	-0.069100	0.997610
NIRSpec	-0.063580	-0.056147	0.996396
MIRI	0.056069	-0.067612	0.996135

- RT Performance:
  - For purposes of this AO, the PI shall assume a maximum wavefront error (WFE) of 131 nanometers (nm) root-mean-square (RMS) at all field points.

3.2.2 Instrument Field-of-View

The NGST Level 2 Requirements, NGST-RQMT-000634, Section 3.2.2.2 defines three non-overlapping fields-of-view (FOVs) for the ISIM SIs. Figure 3-2 illustrates the instruments' (NIRCam, NIRSpec, MIRI) allocated FOVs at the RT focal plane. (**NOTE**: A square FOV, as shown in Figure 3-2, is not an imposed requirement. Square FOVs were used for illustrative purposes only.)

The NIRCam FOV is defined as $16(8/D)^2$ square arc-minutes. For the purposes of the Phase A study, a maximum NIRCam FOV is allocated as 28.4 square arc-minutes (RT D = 6 meters).

The PI shall determine the NIRCam FOV within the above allocation limit. The determination of the NIRCam FOV is dependent upon the selected instrument magnification and the number of pixels incorporated in the FPA.

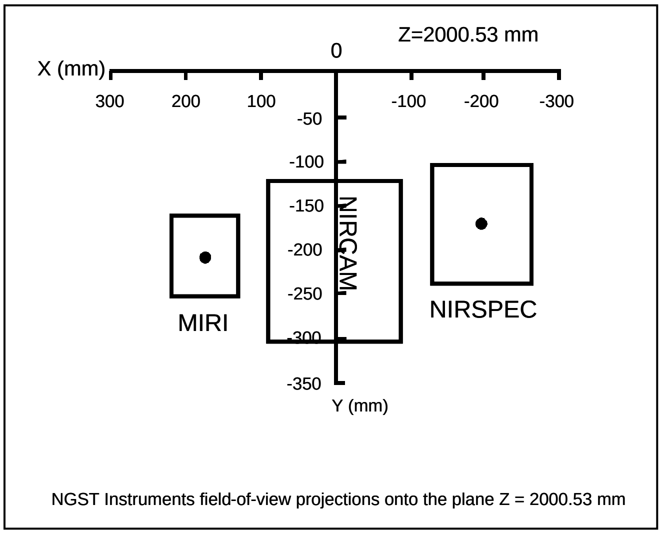

Figure 3-2. Instruments Allocated FOV at the RT Focal Plane

3.2.3 <u>Reference Telescope Focal Plane Access</u>

The NIRCam optically interfaces with the RT by way of a pick-off mirror that is optically part of the NIRCam design, i.e., NIRCam performance shall include the effect of the pick-off mirror.

The NIRCam shares the RT focal plane with the NIRSpec and MIRI. The NIRCam pick-off mirror may be placed to intercept the RT beam anywhere along the direction of the Chief Ray. The NIRCam pick-off mirror shall not vignette the solid volume defined by the extreme field point ray paths for the NIRSpec and MIRI.

NASA, the European Space Agency (ESA), the NIRCam PI, and the MIRI Technical Lead (MTL) will jointly revise/modify the focal plane allocations following selection of the NIRCam PI, the MTL, and the NGST Observatory Prime Contractor.

3.2.4 <u>Wavefront Sensing</u>

The NIRCam instrument focal plane(s) shall be used for Wavefront Sensing (WFS).

The NGST will use focus diverse phase retrieval as the method for establishing a fully coherent aperture that meets the imaging requirements of the optical system. This method uses in-focus and out-of-focus images on the NIRCam focal plane and iterative transform algorithms to determine the end-to-end WFE. The Observatory Wavefront Sensing and Control (WFS&C) subsystem then uses this WFE to determine primary and secondary mirror actuator commands to remove the wavefront error from the system. The WFS&C system will also determine the commands for focus mechanisms incorporated within the SIs to adjust for changes in the location of the OTE focal plane. The Observatory Prime Contractor, who has the responsibility for the WFS&C function, will define the hardware items required for incorporation in the NIRCam Optics Assembly(s).

For purposes of this AO, the WFS hardware shall include six (6) optical elements to be placed at or near a pupil image plane within the NIRCam. Preliminary results from WFS studies/investigations indicate a preference for having a science filter and a WFS optical element in the NIRCam optical path simultaneously. In addition, space shall be reserved for a mechanism/pupil imaging lens that may be inserted in the converging beam in front of the FPA.

If the PI proposes the NIRCam as a single module, the WFS hardware shall be fully redundant. If the PI proposes the NIRCam as a multiple module system, each module shall incorporate the WFS hardware.

Following Observatory Prime Contractor and NIRCam PI selection, negotiations will be held to determine whether NASA (i.e., the Observatory Prime Contractor) or the PI provides these WFS hardware items. (For AO proposal submission, assume that these WFS hardware items are NASA-provided components.)

3.2.4.1 Instrument Focus Mechanism

The NIRCam shall incorporate a focus mechanism ($\pm$2 mm stroke[1]) because, in the process of optimizing the wavefront of the OTE, the optimum location of the secondary mirror may force a change in the location of the OTE Focal Plane.

The Observatory WFS&C subsystem will determine/provide the commands for the NIRCam focus mechanism required to adjust for changes in the location of the OTE Focal Plane.

3.2.5 Optical Error Budget

For purposes of this AO, the NIRCam has been allocated a WFE of 56 nm (RMS). This allocation includes all internal instrument errors and the instrument/ISIM/OTE alignment errors.

Following selection of the Observatory Prime Contractor and the NIRCam contractor, the system allocations of WFE, including NIRCam alignment to/with the ISIM, will be revisited and mutually agreed upon.

3.2.6 Optical Ground Support Equipment

NASA will provide the PI with an optical simulator of the NGST OTE input to the NIRCam. The PI shall define, design, and provide all other Optical Ground Support Equipment (OGSE) required for test of the NIRCam.

3.2.7 Optical Models

The PI shall provide a Code V or Zemax optical model of the NIRCam. If the NIRCam is a multiple module system, models shall be provided for each module.

[1] The 2mm motion is a worst-case estimate – determination of the motion requirements may be determined through discussion with the selected Observatory Prime Contractor during the NIRCam Phase-A study – stroke size will be driven by both WFS and PI science requirements.

3.3 MECHANICAL/STRUCTURAL INTERFACES

3.3.1 ISIM Volume

The back plane/support structure for the RT and the RT/ISIM Structure interface require a "stay out zone" for instrument accommodations that extends 1.07 meters aft (+z direction, Figure 3.1) of the primary mirror vertex. For purposes of this AO, the ISIM volume, within which the Facility Sensor and the SIs (NIRCam, NIRSpec, MIRI) will be accommodated, has been allocated as 15 cubic meters. The volume is defined by two polygonal end caps separated by N meters, where N $\leq$ 3. The light path from the RT will enter the ISIM volume through either one of the polygonal end caps or through one of the N length sides.

3.3.2 NIRCam Volume/Envelope

3.3.2.1 Optics Assembly

The NIRCam Optics Assembly(s) attaches to the ISIM Structure aft (in the +z direction, Figure 3.1) of the RT focal surface.

The NIRCam Optics Assembly is allocated 3.0 cubic meters. This volume includes the pick-off mirror, the NIRCam optical elements, mechanisms, FPA and all associated support structure. The volume does not include the NIRCam "light path" from the OTE FSM to the Instrument pick-off mirror. The volume also does not include the FPE or the ISIM C&DH electronics, which are both remotely located from the Optics Assembly. The NIRCam Optics Assembly may be broken into multiple modules.

Following the selection of the Observatory Prime Contractor, instrument volume allocations and associated envelopes will be determined, reflecting the selected design for the OTE and the ISIM.

3.3.2.1.1 WFS&C Mechanism/Pupil Imaging Lens

For purposes of this AO, the PI shall reserve volume within the NIRCam Optics Assembly(s) for a WFS&C mechanism/pupil imaging lens. The mechanism will translate the pupil image lens into the FOV for WFS&C operations. The mechanism/pupil imaging lens shall be located 50 mm $\pm$TBD mm in front of the FPA. The mechanism/pupil imaging lens dimensions will be determined following selection of the Observatory Prime Contractor.

3.3.2.2 Instrument Control Electronics Box

The Instrument Control Electronics (ICE) box is allocated a maximum envelope (including mounting flange and connector protrusions) of **TBD**mm x **TBD**mm x **TBD**mm.

3.3.3 Mounting

Each NIRCam Optics Assembly shall be mounted to the ISIM Structure using kinematic mounts/flexures. The mounts will be designed, in cooperation with the PI, and supplied by NASA. Location and orientation will be defined following Observatory Prime Contractor selection.

Mounting location and methodology for the ICE will be determined following selection of the Observatory Prime Contractor.

3.3.4 Alignment

Following selection of the Observatory Prime Contractor and the NIRCam PI, the system allocations of WFE, including NIRCam alignment to/with the ISIM, will be revisited and mutually agreed upon.

3.3.5 NIRCam Removal and Installation

The NIRCam package elements shall be designed to be removed and installed during ground operations without degradation, damage or disqualification of the flight hardware. Following Observatory Prime Contractor selection, the orientation of the Observatory/ISIM during NIRCam removal/installation will be determined.

3.3.6 Structural Interfaces

At present, the design limit loads for the NIRCam are 10 Gs in each of the three orthogonal axes, acting one axis at a time. Following selection of the NGST Observatory Prime Contractor and packaging of the ISIM, the NIRCam design limit loads will be finalized.

The fixed-base natural frequency of the NIRCam shall be greater than 50 Hz.

At present, the NIRCam shall be designed in accordance with the General Environmental Verification Specification for STS and ELV Payloads, Subsystems, and Components (GEVS-SE). The GEVS-SE document is available on the web at the following address:

http://arioch.gsfc.nasa.gov/302/gevs-se/toc.htm

Following selection of the NGST Observatory Prime Contractor and the NGST launch vehicle, the environmental verification specifications will be finalized.

3.3.7 Mass Properties

3.3.7.1 Mass

3.3.7.1.2 Optics Assembly

The total mass allocation for the NIRCam Optics Assembly(s) shall be 183 kilograms (kg).

For purposes of this AO, the PI shall assume the following mass allocations which are to be included in the above allocations:

- 0.25 kg for each 2k x 2k element of the FPA
- 0.75 kg total for the six (6) WFS&C filters (per proposed NIRCam Optics Assembly)
- 2.25 kg (per proposed NIRCam Optics Assembly)

If the WFS mechanism/ pupil-imaging lens is incorporated in the NIRCam, the PI will be allocated an additional 6 kg per mechanism.

NOTE: The mass for the FPE and inter-element harnesses are not included in the NIRCam allocations.

The PI shall determine the mass of each NIRCam element/module to within $\pm$0.1kg.

3.3.7.1.2 Instrument Control Electronics

The mass allocation for a single NIRCam ICE shall be 8kg (TBR).

3.3.7.2 Center of Gravity

The PI shall determine the center of gravity of each NIRCam element/module to within $\pm$3mm.

3.3.7.3 Moments of Inertia

The PI shall accurately determine the moments of inertia for each NIRCam element/module to within ±5%.

3.3.8 Angular Momentum

Angular momentum reacted from the Observatory to the Instrument will be less than ***TBD*** Newton-meter-second (N-m-s) per axis. Angular momentum reacted from the Instrument to the Observatory shall be less than ***TBD*** Newton-meter-second (N-m-s) per axis. These values will be determined following selection of the NGST Observatory Prime Contractor.

The reacted angular momentum will be affected by the instrument "set-up" time of ***TBD*** seconds and the instrument contractor's selected mechanism implementation(s).

3.3.9 Contamination Control

At all times, the NIRCam environment shall be maintained at a cleanliness level of class 10,000 or better. As a baseline, particulate contamination shall be Level 300 and molecular contamination shall be Level A, per Product Cleanliness Levels and Contamination Control Program, MIL-STD-1246, or better, at launch.

The PI shall perform a Contamination Redistribution Analysis, particulate and molecular, to verify the above minimum requirements are adequate for NIRCam operation performance. Materials selection shall be related to the results of the molecular redistribution analysis.

3.3.10 Mechanical Ground Support Equipment

The PI shall define, design, and provide all Mechanical Ground Support Equipment (MGSE) required for NIRCam test and for NIRCam installation into and removal from the ISIM.

3.3.11 Instrument Analytical Models

The PI shall provide a NASA Structural Analysis (NASTRAN) structural math model and description. Additionally, the PI shall provide a native Pro/Engineer format or a Standard for the Exchange of Product Model Data (STEP) export format solid model.

3.4 THERMAL INTERFACES

This section provides instrument level thermal interface information. NASA-provided component (FPA) thermal interface information is provided in Section 4.

3.4.1 Thermal Design Overview

Due to the nature of the science goals, very low temperatures must be maintained within the ISIM at all times. In addition, large variations in ISIM and instrument temperatures must be avoided in order to minimize unwanted infrared noise and alignment instability.

The thermal design goal is to achieve a completely isothermal environment for the ISIM/Instruments. To achieve this, warm (room temperature) electronics (power and data handling) will be housed in locations separate from the optical and FPAs. Temperature control within the ISIM will be maintained entirely through passive methods. The SIs will be conductively coupled to the ISIM Structure that transfers heat to an external radiator (nominal operating temperature 29.5K). Strict controls will be placed on the amount of power dissipation and heat transfer from each instrument. Cooling of the NIRCam FPAs will be provided by a direct conductive interface to a dedicated radiator mounted on the ISIM. The ISIM will provide heaters to assure temperature stability and protection during safe-hold and contingency operations.

All information, requirements, and specifications described herein are the total allocations for the NIRCam. If the NIRCam is broken into modules, the PI shall sub-allocate the information, requirements, and specifications to each module.

3.4.2 Conductive Interfaces

The NIRCam Optical Assembly shall be thermally coupled to the ISIM Structure.

3.4.2.1 Mechanical Mounting

The SI complement mounts to the ISIM Structure. Dependent upon the final design, the ISIM Structure will be maintained at a nominal temperature of 30-35K. The transient response of the ISIM Structure will vary by less than 2K during normal operations, including maneuvers. The NIRCam shall be thermally coupled to the ISIM Structure in order to homogenize the overall temperature of the ISIM optics.

3.4.2.2 Harness

Analysis of the NGST harness design indicates 30 milli-watts (mW) of parasitic heat will be conducted into the NIRCam via the harnessing connecting the warm ISIM C&DH electronics to the mechanisms to the Optics Assembly.

3.4.3 Radiative Interfaces

Portions of the instrument will have view factor(s) to other instruments and to the ISIM Structure, all of which will nominally be at the same temperature as the NIRCam (30-35K). Other portions of the instrument will have view factor(s) to the ISIM enclosure. The enclosure will have a nominal temperature of 35K (40K worst case).

The radiative view factors are dependent upon the SI packaging/layout within the ISIM. Following selection of the Observatory Prime Contractor and the SI PIs, the instrument volumes/envelopes will be determined and the radiative view factors determined.

NOTE: ISIM preliminary analyses are assuming a uniform surface emittance of 0.7.

3.4.4 Heat Generation and Dissipation

Total steady state heat dissipation (time-averaged) from the NIRCam mechanisms and PI provided heaters shall not exceed 19 mW. (FPA dissipation is not included in this allocation and will be discussed in Section 4.3.)

3.4.5 Temperature Stability Control

The PI is responsible for determining and providing the temperature stability control required of the NIRCam Optics Assembly (bench, optical elements, mechanisms, etc.). Temperature monitoring of the Optics Assembly will be the responsibility of the PI as well.

NASA, as FPA provider, will be responsible for any required precision temperature stability and monitoring of the FPAs.

3.4.6 Prelaunch and Ground Testing

During this time, the NIRCam shall be held within the temperature range of 18° − 27° Centigrade (C), the relative humidity shall be held between 30 and 50 percent; and the pressure shall be 0.34 − 1.07 atmospheres maximum.

3.4.7 Transportation and Storage

During this time, the NIRCam shall be held within the temperature range of 10° − 32° C; the relative humidity shall be held between 30 and 50 percent; and the pressure shall be 0.34 − 1.07 atmospheres maximum.

3.4.8 Instrument Analytical Models

The PI shall provide geometric and thermal math models and descriptions. These models shall be in either of the following formats:

- *Thermal Synthesizer System* (TSS; geometry) and *Systems Improved Numerical Differencing Analyzer and Fluid Integrator* (SINDA; thermal)
- *Finite Element Modeling and Post-processing* (FEMAP; geometry) and *Thermal Model Generator* (TMG; thermal)

3.5 ELECTRICAL INTERFACES

3.5.1 ISIM Electronics

Electrical interfaces for command and control, calibration control, and engineering telemetry shall be between the NIRCam ICE and the ISIM C&DH. The science data interface is between the NIRCam FPE(s) and the ISIM C&DH.

The ISIM C&DH contains electronics to control SI operations, to perform FPA data manipulation/compression, the ISIM single board computer (SBC), and serial communication card(s). The ISIM C&DH controls and receives data from the FPE and the ICE through separate serial interfaces. Neither the FPE nor the ICE shall have programmable processors.

Electrical interfaces for power shall be between the NIRCam and the Spacecraft (S/C) Power Distribution Unit (PDU).

The ISIM C&DH electronics and S/C PDU are located up to 25m from the Optics Assembly in a 240 - 300K environment. The FPE will be located outside the ISIM cold region, in a 240 − 300K environment, within close proximity to the NIRCam. The ICE will be located outside the ISIM cold region, in a 240 − 300K environment, within **TBD** proximity to the NIRCam.

3.5.1.1 PI Provided Components

The PI shall provide an Instrument Control Electronics (ICE) box. The ICE shall provide mechanism control, calibration source control, engineering telemetry/housekeeping, and power distribution to the NIRCam Optics Assembly. The ICE shall be functionally redundant.

The PI shall provide software objects to be inserted into the flight software (FSW) to configure and control the NIRCam. (NASA will maintain FSW update/configuration control.) Section 5 provides an overview of the ISIM FSW concept.

3.5.2 Harness

NASA will provide the flight harness between the NIRCam and the ISIM C&DH electronics and all harness for the NASA-provided FPA. The PI shall provide all other intra-instrument harnessing.

3.5.3 Connectors

The PI shall use NASA flight approved interface electrical connectors in the NIRCam.

NASA will specify all connectors for the FPA.

3.5.3.1 Connector Usage

Separate connectors, as a goal, shall be used for:

- Power
- Mechanisms, Command/Telemetry, Science Data
- FPA Interface(s)
- Test

Primary and redundant connectors shall be differentiated by clearly marking all units and cables.

3.5.3.2 Spare Pins

Spare pins, 10% per connector, shall be provided.

3.5.4 Power Requirements

All primary power required by/for the NIRCam modules will be provided by the S/C PDU. The NIRCam ICE shall incorporate secondary power generation/distribution.

3.5.4.1 Input Voltage

The S/C PDU will provide 28 +/-7 volts DC. Power characteristics will be determined/provided following selection of the Observatory Prime Contractor.

3.5.4.2 Operating Power

The operating power allocation includes the power required for the control cards, harness losses, and the mechanism/calibration device(s) in the Optics Assembly.

The average operating power for the NIRCam shall not exceed 17 watts (W) (TBR). The allowable peak power will be defined in the NIRCam ICD. The ICE redundant electronics shall not be powered when not in use.

3.5.4.3 Power Fault Isolation

No power fault isolation shall be incorporated within the NIRCam. Power fault isolation will be included only on the spacecraft side of interfaces, i.e., between the spacecraft and the ICE.

3.5.5 Grounding

The NIRCam shall conform to the ISIM grounding methodology as shown in Figure 3-3

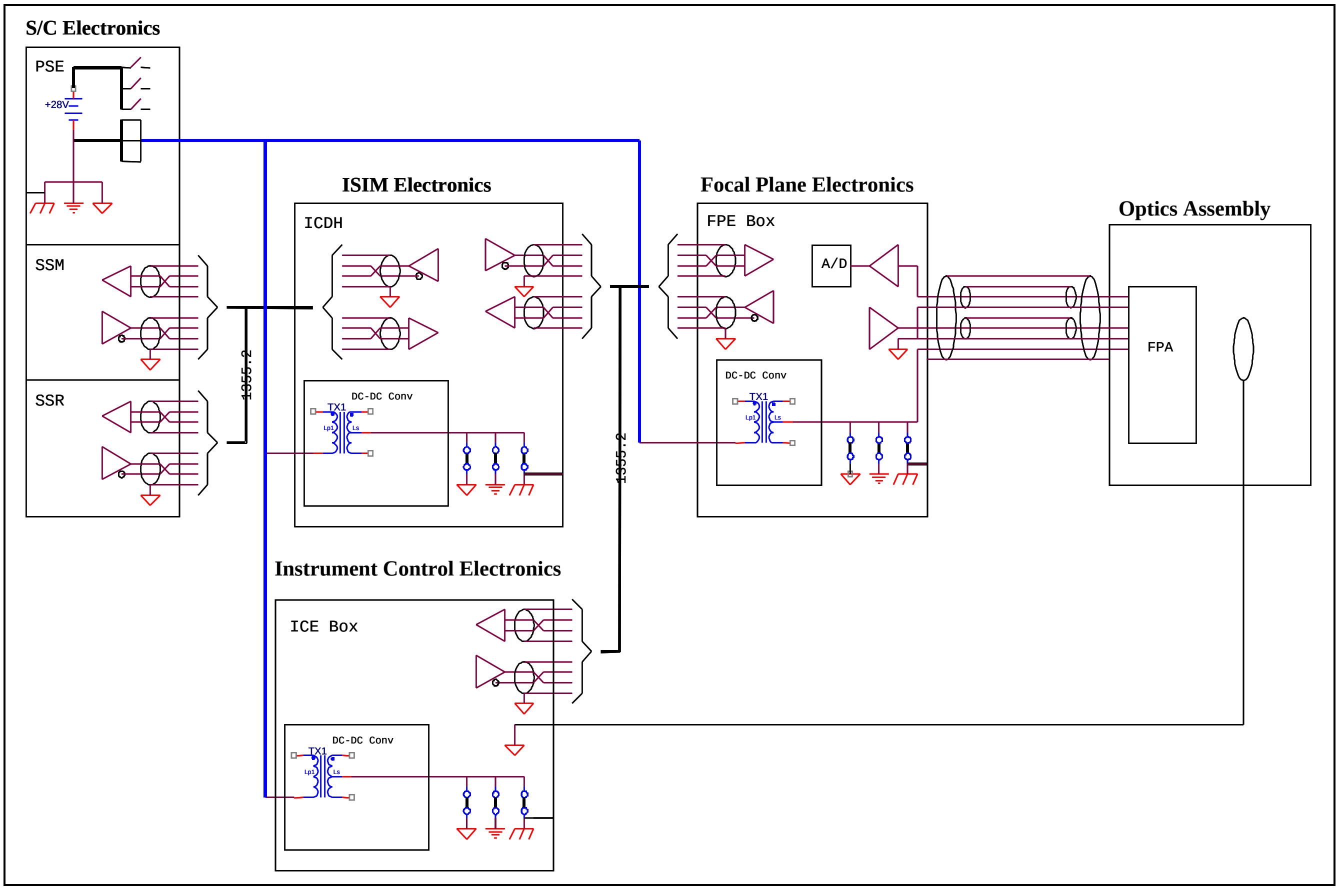

Figure 3-3. ISIM Grounding Concept

3.5.6 <u>Radiation Environment</u>

The Instrument shall be designed to operate after exposure to the radiation environment associated with low earth orbit, and during and after exposure to the radiation environment associated with transfer to and operation at L2. The expected radiation environment is detailed in NGST-RPT-000453, Radiation Environment for the Next Generation Space Telescope (NGST web page (**http://ngst.gsfc.nasa.gov/**) download document #570)

3.5.7 <u>Electromagnetic Interference</u>

3.5.7.1 Conducted Emissions

The NIRCam shall comply with the requirements for conducted emissions as specified in GEVS-SE, Sections 2.5.2.1a (narrow band emissions), 2.5.2.1b (common mode noise), and 2.5.2.1c (broadband emissions).

3.5.7.2 Conducted Susceptibility

No requirements have been identified per GEVS-SE, Section 2.5.3.1.

3.5.7.3 Conducted Transient Susceptibility

The NIRCam shall comply with the requirements for conducted transient susceptibility as specified in GEVS-SE Section 2.5.3.1e (power line transients).

3.5.7.4 Radiated Emissions

The NIRCam shall comply with the requirements for radiated emissions as specified in GEVS-SE Section 2.5.2.2c (unintentionally radiated narrowband) and 2.5.2.2d (unintentionally radiated broadband).

3.5.8 Electrical Ground Support Equipment

NASA will provide breadboard and engineering models of a Test Set for use during NIRCam integration and test. The provided equipment will be comprised of a Ground System simulator, a S/C simulator, a Solid-State Recorder (SSR) simulator, and ISIM C&DH electronics (FPAP, power supply, and ISIM computer with "flight" software installed).

NASA will provide all required electronics and software for operation of the FPA. NASA will also provide test harness for the FPA.

The PI shall define, design, and provide all other Electrical Ground Support Equipment (EGSE) (including mechanisms and calibration source controller/engineering telemetry/housekeeping card test harness) required for testing of the NIRCam at the instrument contractor's facility, at the ISIM Integration and Test Facility, and at the NGST Observatory Integration and Test Facility.

The EGSE shall include the capability to ingest/evaluate all instrument data.

3.6 RELIABILITY

The PI shall assure the NIRCam design is sufficiently robust such that the science function is maintained following failure of any single component.

4.0 DETECTOR/FOCAL PLANE ASSEMBLY INTERFACES

NASA will provide the PI with the NIRCam FPA and its associated FPE for command/control/data handling. NASA has the responsibility to assure the performance of the FPA/FPE meets the requirements.

This section establishes the specific interface requirements for the accommodation of the FPA within the NIRCam.

The FPA is an NGST Technology Development component. Two separate developments are on going. The FPA is being developed to the following requirements: Technology Development Requirements and Goals for the NGST Detectors, NGST-RQMT-000787.This document may be accessed through the NGST public web site (**http://ngst.gsfc.nasa.gov/**) as document #641.

Following FPA contractor selection, this section will be revised/modified.

4.1 OPTICAL INTERFACE

For purposes of this AO, the FPA will be an array of Sensor Chip Assemblies (SCA). Each SCA will be:

- Square
- A 2048 x 2048 pixel array with 20 micron center-to-center spacing

NOTE: The actual flight SCA will have a different pixel-to-pixel dimension than the study SCA.

4.2 MECHANICAL/STRUCTURAL INTERFACE

The PI shall provide all structural elements required to support the FPA.

The NIRCam shall be designed to provide access to allow FPA removal, installation or replacement during ground operations without degradation, damage or disqualification of the flight hardware. Following Observatory Prime Contractor selection, the orientation of the Observatory/ISIM during FPA removal, installation or replacement will be determined.

4.2.1 Envelope

The FPA envelope is dependent upon the FPA configuration proposed by the PI.

For purposes of this AO, the PI shall use the following packaging concept to determine an envelope for the proposed FPA configuration:

- Each SCA active area measures 40.96mm x 40.96mm
- SCA separation measures approximately 5mm
- The set of SCAs is mounted on a motherboard which is 25mm larger (per side) than the SCAs (including inter-SCA spacing)
- The overall depth of the FPA measures 50mm

4.2.2 Mass

For purposes of this AO, the PI shall assume the following mass allocation for the FPA: 0.25 kg for each 2k x 2k SCA incorporated in the FPA(s). This allocation incorporates the SCAs and the motherboard mass.

4.3 THERMAL INTERFACE

4.3.1 Conductive Interface

The PI shall design the FPA support structure such that the FPA is highly thermally isolated from the NIRCam instrument bench in order to minimize parasitic heat transfer from the NIRCam instrument bench to the FPA.

The FPAs will be connected to an ISIM-provided radiator that will cool the assemblies to 30K (nominal). NASA provided thermal straps (possibly copper or aluminum, one per FPA) will provide this connection. The thermal strap between the FPA and the radiator will be designed to minimize the FPA-to-radiator thermal gradient to less than 0.5K. The FPA vendor will provide the FPA-to-strap interface. This interface will be designed to maximize thermal contact between the FPA and the thermal strap.

The NIRCam has been allocated a total of 150mW heat transfer to the thermal strap for all FPAs. This includes the heat generated by the FPA, harness parasitics, and instrument parasitics through the FPA support structure.

4.3.1.1 SCA Heat Generation/Dissipation

The specification to which the FPA is being developed has allocated each SCA a maximum heat dissipation of 4mw.

4.3.1.2 Harness Parasitics

Analysis of the NGST harness design indicates 2.5mW of parasitic heat will be conducted into each SCA via the harnessing connecting the warm focal plane electronics to the FPA.

4.3.2 Radiative Interfaces

The PI shall determine the FPA radiative interfaces within the NIRCam.

4.3.3 Temperature Stability Control

NASA, as FPA provider, will be responsible for any required precision temperature stability and monitoring of the FPA. (The required temperature stability is unknown at this time. Anticipated SCA testing in early 2002 is expected to yield this data.)

4.4 ELECTRICAL INTERFACES

NASA, as FPA provider, will be responsible for all electrical interfaces with the FPA.

4.5 CONTROL AND DATA HANDLING SOFTWARE

NASA, as FPA provider, will be responsible for all C&DH software for the FPA.

4.6 RELIABILITY

The Instrument designer shall implement the FPA realizing that each SCA is a single fault device. This means that a single failure, such as loss of any clock, power, command/control, data input/output (I/O), will render the SCA inoperative.

5.0 NIRCAM FLIGHT SOFTWARE INTERFACES

This section presents requirements for the interfaces between SI FSW components and ISIM Flight Data System Software (FDSS) components as they occur both in the development and integration environments as well as the operational flight environment. These requirements have been identified pursuant to the following goals:

- Ensure proper operation of all SI FSW and the ISIM FDSS on orbit.
- Contain cost and complexity of processes for integration and testing of all SI FSW with the ISIM FDSS.
- Contain cost and complexity of processes for on-orbit maintenance of all integrated SI FSW and ISIM FDSS.

An overview of the software components is provided below followed by the interface requirements, which are organized into four categories:

(1) Functional interface requirements describe how the SI FSW and the ISIM FDSS exchange information, and request and provide services;

(2) Resource interface requirements specify how much of the available ISIM Flight Data System (FDS) processing resources are allocated to the SI FSW;

(3) Software compatibility interface requirements specify the essential characteristics of the SI FSW that promote smooth, trouble-free integration of the software components; and

(4) Development and maintenance interface requirements specify the conditions that must be met to enable effective control and tracking of FSW configurations consisting of components from multiple providers.

While the requirements in this section specifically address the NIRCam instrument, they are similar for all instruments. All references to SI in this section shall be interpreted to mean NIRCam as well as the other SIs.

5.1 FLIGHT SOFTWARE OVERVIEW

The NGST has a FDS residing in both of the major physical modules, the ISIM and the Spacecraft Support Module (SSM). The FDS in both of these modules will contain its own C&DH software subsystem. Both of these C&DH subsystems will include an identical kernel software element called the Common Command and Data Handling (Common C&DH). In addition to the Common C&DH kernel, each C&DH subsystem will include interface and application software elements that are specific to that module. Figure 5-1 shows a functional model of the NGST FSW.

Each SI will have two types of SI FSW that must be integrated into the ISIM FDS. SI application software will use the services of the ISIM C&DH. SI hardware interface software, which provides device-level interaction with the SI hardware, must be integrated into the ISIM C&DH subsystem. The NIRCam FSW functions are highlighted in Figure 5-1.

The Common C&DH software is being developed by an Integrated Product Team at the Goddard Space Flight Center (GSFC) in Greenbelt, Maryland. The SI hardware interface software will be developed jointly by the SI FSW Development Team and the ISIM FSW Development Team. The SI Team will define requirements and specifications for the hardware interface software; the ISIM team will design, code and unit test the software, and the SI Team will perform system level testing in their SI FSW development lab.

The SI Applications will be developed by SI FSW Development Team and integrated into the ISIM FDS by the ISIM FSW Development Team. Integrated ISIM FDSS builds will be released to the SI FSW Development Team periodically.

The ISIM FSW Development Team at GSFC will develop the FPA readout interface and associated control applications. These control applications provide FPA control using exposure time and readout method as parameters. The FPAs are read in accordance with dynamically supplied control parameters, and the data is read from the FPA processor cards and transferred to the Solid State Recorder (SSR). Interfaces between FPA software and SI FSW will be designed jointly by the ISIM and SI FSW Development Teams.

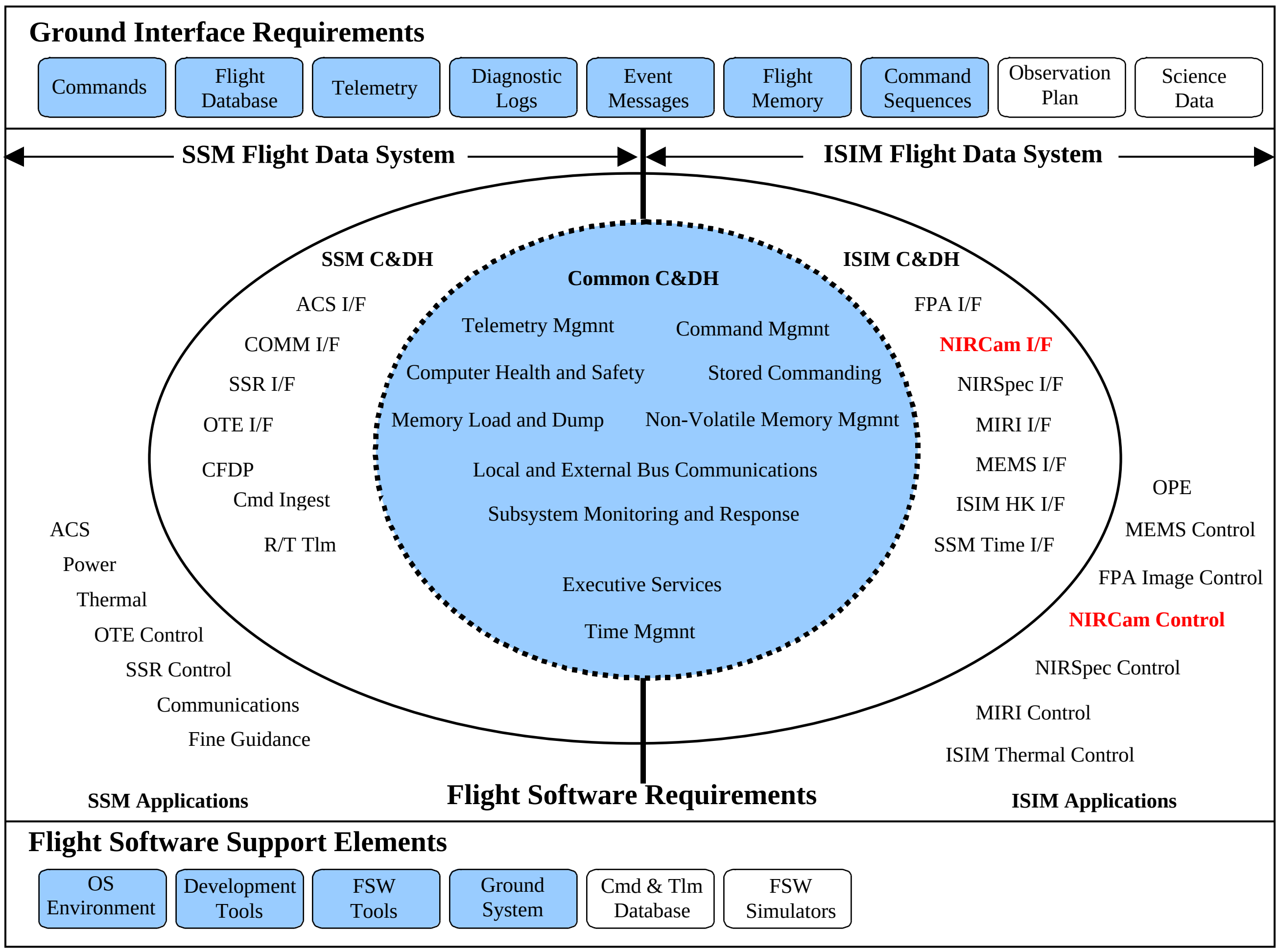

Figure 5-1. NGST Flight Software Functional Model

5.1.1 Science Instrument Software Components

Each SI will have two types of software. There will be an application component for effecting control of the instrument, called the SI Control application. There will also be a system support component for interfacing the ISIM C&DH software to the SI hardware, called the SI Hardware Interface component. These SI software components share resources with all other software executing in the ISIM FDS. Figure 5-2 shows the architecture of the ISIM FSW and the placement of the NIRCam Control application and the NIRCam Hardware Interface (system support layer) components.

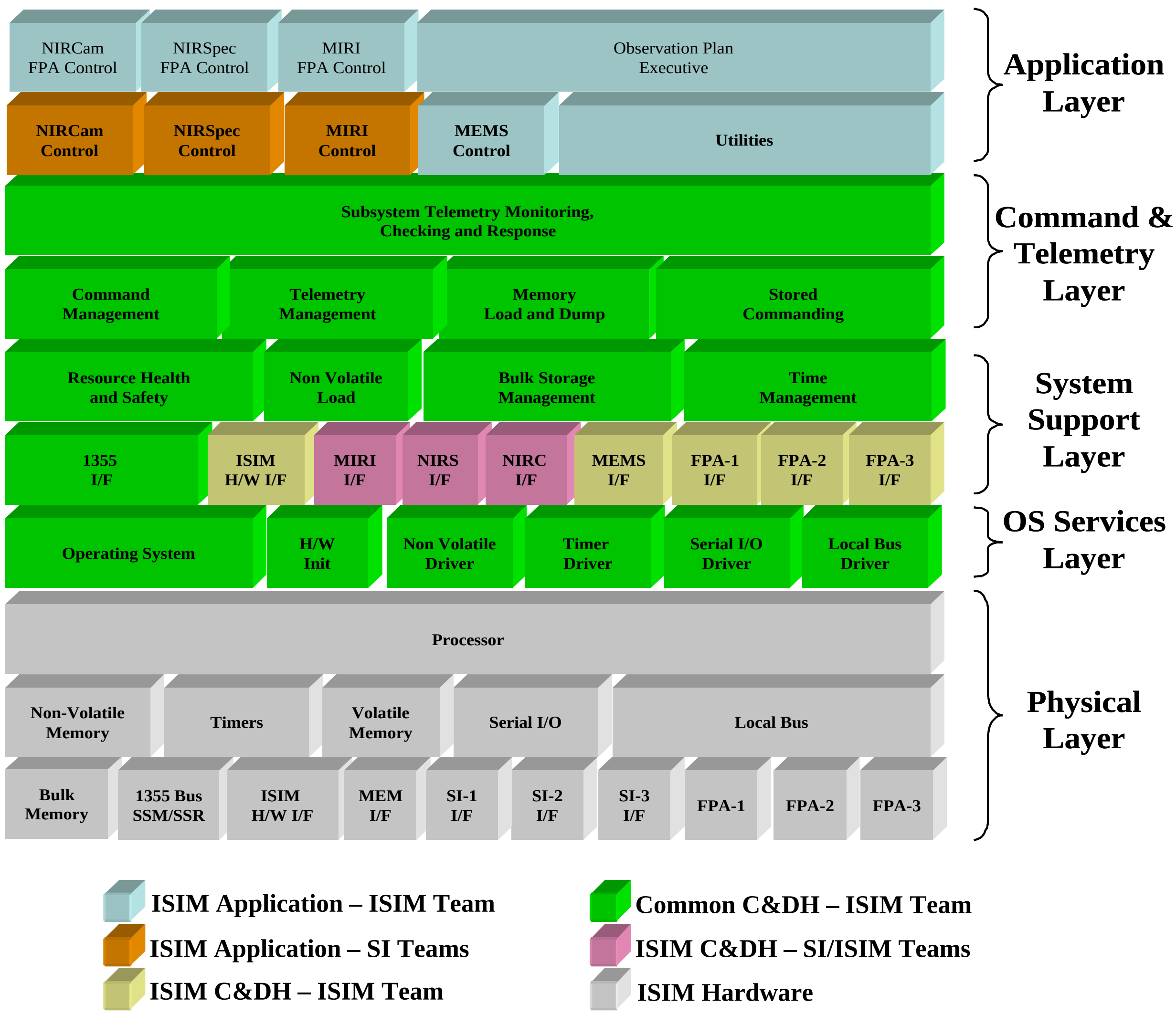

Figure 5-2. Architecture of the ISIM Flight Data System

The SI Control applications, shown in Figure 5-2 (application layer, lower row, left end), will contain computationally intensive tasks and will manage all high-level mechanism, calibration, and housekeeping activities. All communication between SI Control applications and other application components will be via ISIM C&DH services. Likewise all commanding done by the SI Control applications will be performed using ISIM C&DH services. Since communications with SI Control applications are managed by the ISIM C&DH, the SI Control applications are platform and operating system independent.

The SI Hardware Interface components will be embedded into the ISIM C&DH. This component is analogous to an operating system device driver. A hardware interface component is a collection of software routines to control and exchange information with a hardware device. These routines convert general control operations (configure, write, and read) to specific operations designed for the device. Typically, interrupt routines will be included as part of a hardware interface component. These components are platform and operating system dependent.

The SI software components will be functionally verified by the SI FSW Development Team, and delivered to the ISIM FSW Development Team for formal software integration.

5.1.2 ISIM Command and Data Handling Software Component

The Common C&DH software, the kernel of the ISIM C&DH, provides all SI Control applications with a set of standard system services, as described below.

There is a communication service that manages all data I/O from application to application. This service includes the routing of messages between single or multiple processors, validating inter-task message traffic, protecting the integrity of the data, and message error reporting. The Common C&DH software is responsible for managing onboard commands and data. This includes all I/O operations to local hardware connected to the central processing unit (CPU) backplane, all external bus communication, and all memory mapping.

The Common C&DH software provides a time service for spacecraft time maintenance and distribution.

The Common C&DH software provides an interface service for all non-volatile memory. One function of this service is to facilitate the synchronization of SI application software table loading and dumping.

In addition to providing services for application software, the Common C&DH software manages the CPU health and safety. The Common C&DH contains a stored command processing function that includes SI software telemetry monitoring and limit checking. These combined functions will perform failure detection and correction and will execute safing procedures for SI software and other subsystems. The SI Control applications will not use the stored-command function for absolute-time commanding since the Observation Plan Executive (OPE) provides this function (see 5.1.3 below).

The Common C&DH kernel may be viewed as an extension of the operating system. An operating system kernel generally provides functions for priority based task scheduling, inter-task communications and synchronization, memory management, and real-time clock services. The Common C&DH provides an operating system independent layer of services to the applications so the applications may be used across hardware and operating system platforms.

The Common C&DH software interfaces will be defined in the NGST Common C&DH Interface Control Document, NGST-ICD-000695.

Additional details are provided in the sections below, and the Common C&DH Requirements are available on the NGST Web Page (www.ngst.nasa.gov) under 'Online Documents'.

5.1.3 ISIM Flight Software Applications

There are two ISIM application software components of significant interest. The first is the OPE and the second is the FPA Control Application.

5.1.3.1 Observation Plan Executive Applications

NGST Mission Operations will use an event-driven operating paradigm, normally free of absolute-time-tagged commanding. This will be accomplished with a FSW application component resident in the ISIM FDS called the OPE. High-level observation plans will be up-linked from the ground to the OPE. The OPE will execute these plans and dynamically respond to real-time events using a set of predefined, onboard rules. The OPE will interface to the SSM Attitude Control System (ACS) over an external SpaceWire bus to achieve and maintain the desired pointing with the required pointing accuracy. The OPE will direct observations and issue commands to the SI Control applications and other FSW components. This paradigm will simplify ground-system procedures for observatory scheduling and operations, enabling more efficient use of observatory resources. The OPE will insert standard housekeeping activities during available time slots.

The ground-based planning and scheduling system constructs an observation plan for the OPE to execute on a regular (for example, weekly) basis. The new plan is up-linked and appended to the end of the currently executing plan, so there need be no gap in execution. Each plan is composed of progressively smaller structural units called visits, groups, sequences, and activities.

An activity is the smallest logical unit uploaded from the ground for dissemination by the OPE. Some typical activities are Slew, Acquire Guide Star, Acquire NIRSpec Target, and Acquire NIRCam Exposure. Each activity has a number of associated parameters, both generic and specific. Generic parameters include the identification (ID) of the target application (e.g., AOC, indicating Attitude/Orbit Control, for a Slew activity), and a flag indicating whether successful completion of the activity is required for the visit as a whole. Specific parameters are required to define each activity, such as target destination for a slew, as well as special conditions that must be met before the activity starts, such as sufficiently low spacecraft jitter for a guide star acquisition.

A sequence is a set of one or more activities to be executed sequentially (e.g., Slew, Acquire Guide Star, Acquire NIRCam Exposure).

A group is a set of one or more sequences to be executed in parallel.

A visit is a logically complete set of one or more groups. Visits typically consist of a slew to a particular target attitude, followed by a number of science or engineering activities at that attitude. A visit may also have associated parameters, in particular a set of three time parameters: an earliest permitted start time, latest permitted start time, and latest permitted end time. These can be used accomplish a variety of scheduling constraints, such as:

- Force the visit to coincide with an anticipated astronomical event.
- Coordinate the visit with other observatories for related observations.
- Prevent a visit from starting before its attitude would be valid or continuing after its attitude has become invalid.
- Terminate a visit if its continuation would cause it to encroach upon time required by the next, presumably higher priority, visit.

Additional details are provided below, and OPE functional requirements are available on the NGST Web Page (www.ngst.nasa.gov) under online documents.

5.1.3.2 FPA Control Application

The ISIM FSW Development Team will develop all ISIM FPA software components.

The FPA Control application will provide control of the FPE and the FPA Processor (FPAP) cards in the ISIM C&DH. The FPE has four SCA interface cards that provide the actual timing and Digital-to-Analog conversion and transfer of the data to the FPAP cards for sample method processing. Sampling methods under consideration are Up-the-Ramp, Fowler, and Multi-Accumulation. The SI Control applications will utilize this software to manage all FPA control.

5.2 FUNCTIONAL INTERFACE REQUIREMENTS

5.2.1 Functional Component Interface

The NIRCam FSW shall consist of two software components, a NIRCam Control application and a NIRCam Hardware Interface component.

The NIRCam Control application shall provide NIRCam mechanism control and management. The NASA ISIM Software Team will provide FPA control and management software.

- The NIRCam Control application shall interface with the ISIM C&DH in accordance with the NGST Common C&DH FSW Requirement Specification and the NGST Common C&DH Interface Control Document. **NOTE:** The Common C&DH software Integrated Product Team (IPT) will develop these documents. The ICD shall include, but not be limited to, communication protocols, software maintenance, database table load and dump, time, health and safety status, packet formats and message response times.

- The NIRCam Control application shall execute as an ISIM Software Application with regard to invocation, inter-application communication, I/O operations, event logging, and error handling.

- The NIRCam Control application shall interface with the OPE via the ISIM C&DH. When the OPE issues an activity request to the NIRCam Control application, the NIRCam Control application shall respond to the OPE with an appropriate status message.

- The NIRCam Control application shall not communicate directly with the real-time operating system. The ISIM C&DH will provide the authorized operating system services.

The NIRCam Hardware Interface component shall execute as an ISIM C&DH component. The NIRCam Hardware Interface component shall interface with the Common C&DH in accordance with the ISIM to NIRCam ICD.

- The NIRCam Hardware Interface component shall receive and send data between the NIRCam Instrument and the ISIM C&DH using a SpaceWire (IEEE 1355) (TBR) interface.

5.2.2 Telemetry Interface

Telemetry filtering will be performed by the ISIM C&DH telemetry filtering function. Telemetry filtering is described in the NGST Common C&DH FSW Requirement Specification. ISIM and NIRCam system engineering personnel shall negotiate filter tables for all NIRCam telemetry operations based on availability of resources and monitoring requirements.

SI software telemetry generation shall be specified by the frequency of desired samples. The following requirements specify maximum frequency (no telemetry packet shall be generated faster than the maximum rate), however, lower rates are acceptable.

- During normal operations, high-frequency telemetry items shall be included in a single high-frequency packet with the maximum frequency being 10 Hz (10 packets per second).

- During normal operations, medium-frequency telemetry items shall be included in a single medium-frequency telemetry packet with the maximum frequency being 0.25 Hz (one packet every four seconds).

- During normal operations, low-frequency telemetry items shall be included in a single low-frequency telemetry packet with the maximum frequency being 0.0333 Hz (one packet every 30 seconds).

- During non-normal operational scenarios, diagnostic telemetry items shall be included into a maximum of four different diagnostic packets that can be commanded for short durations. The total available ISIM resources limit diagnostic packet frequencies.

5.2.3 Commanding Interface

All NIRCam Control application command interfaces (e.g., receive/send commands from/to the ground, the OPE, or onboard stored command sequences) shall be via the ISIM C&DH.

All NIRCam Hardware Interface component command interface (send/receive) with the NIRCam Control component shall be via the ISIM C&DH.

If NIRCam safing command sequences or failure detection and corrective command sequences are required, the NIRCam Control application shall utilize the ISIM C&DH software monitor and limit checking facility and the stored command sequence facility to implement these procedures.

5.3 RESOURCE INTERFACE ALLOCATIONS

The SI application shares resources with all other ISIM components.

5.3.1 NIRCam Control Component Allocations

The SI FSW Development Team shall develop the NIRCam Control component within the following allocations. **NOTE**: If the PI proposes the NIRCam as multiple modules, these allocations are the total allocation for all NIRCam modules.

5.3.1.1 Processing

The NIRCam Control component shall have a processing allocation of 4.5 Million Instructions Per Second (MIPS) (i.e., 4.5% of a 100 MIPS machine). This allocation is based on machine-level instructions not source code instructions.

5.3.1.2 Volatile Memory

The NIRCam Control component shall have a volatile memory allocation of 5.5 megabytes (MB). This includes all code and data areas required for the application.

5.3.1.3 Non-Volatile Memory

The NIRCam Control component shall have a non-volatile memory allocation of 2.5 MB. This is based on not having volatile data areas stored in non-volatile memory and compressing the non-volatile code component.

5.3.2 NIRCam Hardware Interface Component Allocations

The ISIM FSW Development Team will develop the NIRCam Hardware Interface component. All allocations (processing, volatile memory, and non-volatile memory) for the Hardware Interface component are included in the overall ISIM C&DH allocations.

5.4 SOFTWARE COMPATIBILITY REQUIREMENTS

All NIRCam software components shall adhere to the NGST FSW Coding Standards Document.

All NIRCam software components shall be developed using C and/or C++ language.

All NIRCam software components shall allocate memory at NIRCam software startup. No dynamic memory allocation shall be permitted after initialization.

The NGST Program has standardized on using Rational Rose Real-Time for developing flight software. The NIRCam Control Component shall be developed using this system.

The NIRCam Control application shall communicate with the Common C&DH using the command and telemetry specification developed by the Common C&DH software IPT and documented in the NGST Common C&DH Interface Control Document.

5.5 DEVELOPMENT AND MAINTENANCE INTERFACE REQUIREMENTS

The NIRCam software team shall not patch or update the ISIM C&DH software. All changes to the Common C&DH shall be coordinated through the Common C&DH IPT.

Each NIRCam software delivery shall include source code, object files, executables, make files and ICDs, and shall be accompanied by a Version Description Document (VDD) that specifies the features or modifications that distinguish the delivery.

NIRCam software configuration management, including version designation and control, shall be coordinated between the ISIM FSW Development Team and the NIRCam FSW Development Team.

NIRCam software discrepancy reports and change requests shall be entered into the ISIM web-based Discrepancy/Change Request system.

6.0 INSTRUMENT OPERATION

6.1 BACKGROUND

Experience with on-orbit operations with a variety of science missions, both astronomy and earth observing, has shown that instrument operational complexity is a major cost driver through the operational lifetime. NGST expects to be operating for at least 10 years. Therefore, all NGST SIs shall be as operationally simple as practicable

6.2 OPERATIONAL MODES

The operational modes of each SI shall be limited to those that are required to carry out the highest priority science programs as reflected in the NGST Level 1 and Level 2 documents. An operating mode is any basic configuration of the instrument, either mechanical or electrical intended, to carry out a separate task in the operation of the instrument. The number of modes is ***TBD*** at this time.

6.3 OPERATIONS PLANNING WORKING GROUP

It is planned that an Operations Planning Working Group will be established, with representation from the science and engineering staff of each instrument team (NIRCam, NIRSpec, MIRI), to develop a detailed description of how each instrument will be operated. This Working Group will develop an operations and management plan for each instrument. These plans will be used as a basis of estimate for operations costs, and to define engineering requirements. These plans will contain a complete walk-through of science operations for each instrument, detailed requirements for all operational modes, and operational requirements for each mechanism.

APPENDIX A. ABBREVIATIONS AND ACRONYMS LIST

ABBREVIATIONS AND ACRONYM LIST

A/D	Analog/Digital
ACS	Attitude Control System
AO	Announcement of Opportunity
AOC	Attitude/Orbit Control
C	Centigrade
C&DH	Command and Data Handling
CCSDS	Consultative Committee for Space Data Systems
CFDP	CCSDS File Delivery Protocol
Cmd	Command
COMM	Communications
CPCI	Compact Peripheral Component Interconnect
CPU	Central Processor Unit
DCR	Discrepancy/Change Request
EGSE	Electrical Ground Support Equipment
ELV	Expendable Launch Vehicle
ESA	European Space Agency
FDSS	Flight Data System Software
FEMAP	Finite Element Modeling and Post-processing
FGS	Fine Guidance Sensor
FOV	Field of View
FPA	Focal Plane Assembly
FPAP	FPA Processor
FPE	Focal Plane Electronics
FSM	Fast Steering Mirror
FSW	Flight Software
GEVS-SE	General Environmental Verification Specification for STS and ELV Payloads
GSFC	Goddard Space Flight Center
HK	Housekeeping
Hz	Hertz
I/F	Interface
I/O	Input/Output
ICD	Interface Control Document
ICE	Instrument control Electronics
ID	Identification
ISIM	Integrated Science Instrument Module
K	Kelvin
kg	Kilogram(s)
m	Meter
MB	Megabytes
MEMS	Micro-electromechanical System
MGSE	Mechanical Ground Support Equipment
MIPS	Million Instructions Per Second
MIRI	Mid Infrared Instrument
mm	Milli-meter
MTL	MIRI Technical Lead
mW	Milli-watt
NASA	National Aeronautics and Space Administration
NASTRAN	NASA Structural Analysis

ABBREVIATIONS AND ACRONYM LIST (continued)

NGST	Next Generation Space Telescope
NIRCam	Near Infrared Camera
NIRSpec	Near Infrared Spectrometer
nm	Nano-meter
N-m-s	Newton meter second
OGSE	Optical Ground Support Equipment
OPE	Observation Plan Executive
OS	Operating System
OTE	Optical Telescope Element
PDU	Power distribution Unit
PI	Principle Investigator
PWB	Printed Wiring Board(s)
RMS	Root mean square
RT	Reference Telescope
SBC	Single Board Computer
S/C	Spacecraft
SCA	Sensor Chip Assembly
SI	Science Instrument(s)
SINDA	Systems Improved Numerical Differencing Analyzer and Fluid Integrator
SSM	Spacecraft Support Module
SSR	Solid State Recorder
STEP	Standard for the Exchange of Product Model Data
Tlm	Telemetry
TMG	Thermal Model Generator
TSS	Thermal Synthesizer System
V	Volt(s)
VDD	Version Description Document
WFS	Wavefront Sensing
WFSC&S	Wavefront Sensing and Control